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DU (DEPLETED URANIUM) CHIP RECOVERY PROGRAM PHASE I A  
MACHINING STUDY FOR (U) SOUTH CREEK INDUSTRIES INC  
REXFORD NY J CONBOY ET AL JUL 83 AMMRC-TR-83-42

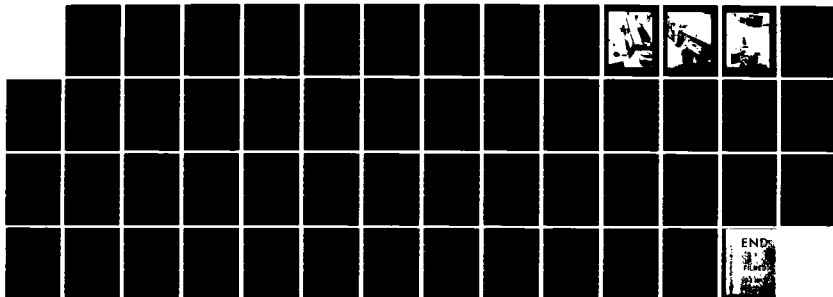
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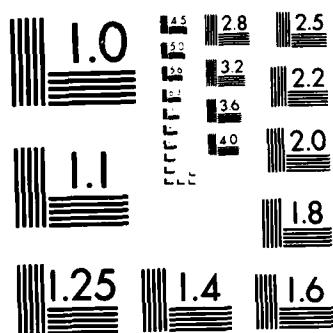
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AMMRC TR 83-42

DU CHIP RECOVERY PROGRAM, PHASE I -  
A Machining Study for the Production of Contaminant-Free Chips

July 1983

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FINAL REPORT

Contract No. DAAG46-83-C-0004

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Prepared for

ARMY MATERIALS AND MECHANICS RESEARCH CENTER  
Watertown, Massachusetts 02172

U.S. ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND  
Dover, New Jersey 07801

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ABSTRACT

The present depleted uranium (DU) machining process used in the production of the M774 and M833 DU penetrators incurs excessive costs due to the necessity for burial of the radioactive metal turnings (chips). The alternative to burial was the recycling of the chips to form usable depleted uranium thereby eliminating disposal problems and increasing the supply of depleted uranium. An inert atmosphere was proposed to produce contaminate-free chips that will allow remelting to required chemical specifications of the penetrator material. A lathe enclosure was designed to provide a controlled atmosphere of argon gas maintaining a positive pressure of 0.25 psi within. Dry argon gas was used as a coolant at the tool workpiece interface. The chips were analyzed for oxygen and carbon content; the contaminants most critical to the remelting of the chips. The chemical analysis showed consistently low oxygen and carbon "pick-up." The significance of these results was substantiated by the successful melting of depleted uranium chips in an electric resistance furnace at AMMRC.

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### PREFACE

This is the final report, Phase I under Contract DAAG46-83-C-0004 covering the period from January 5, 1983 to July 5, 1983. The program sponsored by U.S. Army Armament Research and Development Command is being monitored by the Army Materials and Mechanics Research Center (AMMRC), Watertown, Massachusetts. Mr. H. Whitney of AMMRC is the contracting officer's technical representative.



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2.0

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2.1

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2.3

A P P E N D I C E S

<u>APPENDIX #</u>	<u>DESCRIPTION</u>
A	TEST PROCEDURE
B	TEST DATA SHEETS

### 3.0 GENERAL SCOPE

To date, an economical process for the recovery of depleted uranium metal turnings does not exist. The burial of these radioactive chips has an appreciable cost impact on the overall production of the M774 and M833 DU penetrators.

Under this contract, an investigation was made to provide a system to produce "contaminant-free" DU chips that would be suitable for subsequent reprocessing into a usable solid mass.

#### 3.1 ENCLOSURE

South Creek Industries, Inc. (SCI) designed, fabricated and installed a controlled atmosphere chamber (as shown in Figures 1 through 4) on a Pratt & Whitney 12" Model "C" lathe at the AMMRC DU machining facility. The chamber provided an inert or "non-oxidizing" atmosphere, surrounding the workpiece during the machining operations.

#### 3.2 TOOL HOLDER/INSERTS

A specially adapted tool holder and cutting inserts were fabricated for the machining operations. Using an EDM drilling technique, a tool holder and ten (10) carbide inserts were fabricated, as shown in Figure 5. The purpose of this approach was to provide an internal coolant (argon) passage through the tool to the workpiece as an added cooling effect.

#### 3.3 COOLANT/ATMOSPHERE

It was originally intended that liquid argon would be used as a source of coolant gas to the workpiece. Preliminary "check-out" tests indicated that "dry" argon gas was adequate to provide the necessary cooling to the tool and the test bars.

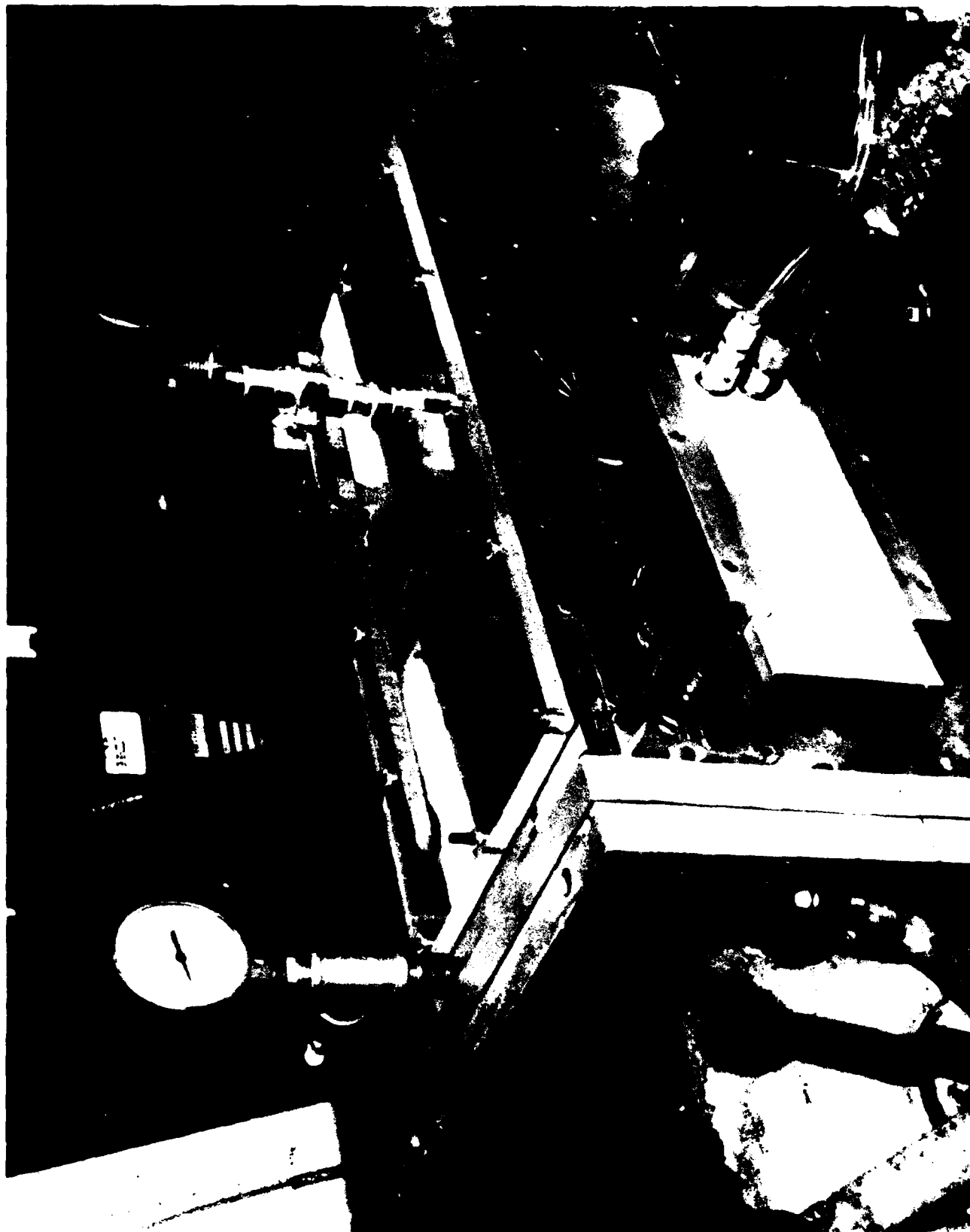


FIGURE 1 - SIDE VIEW ENCLOSURE

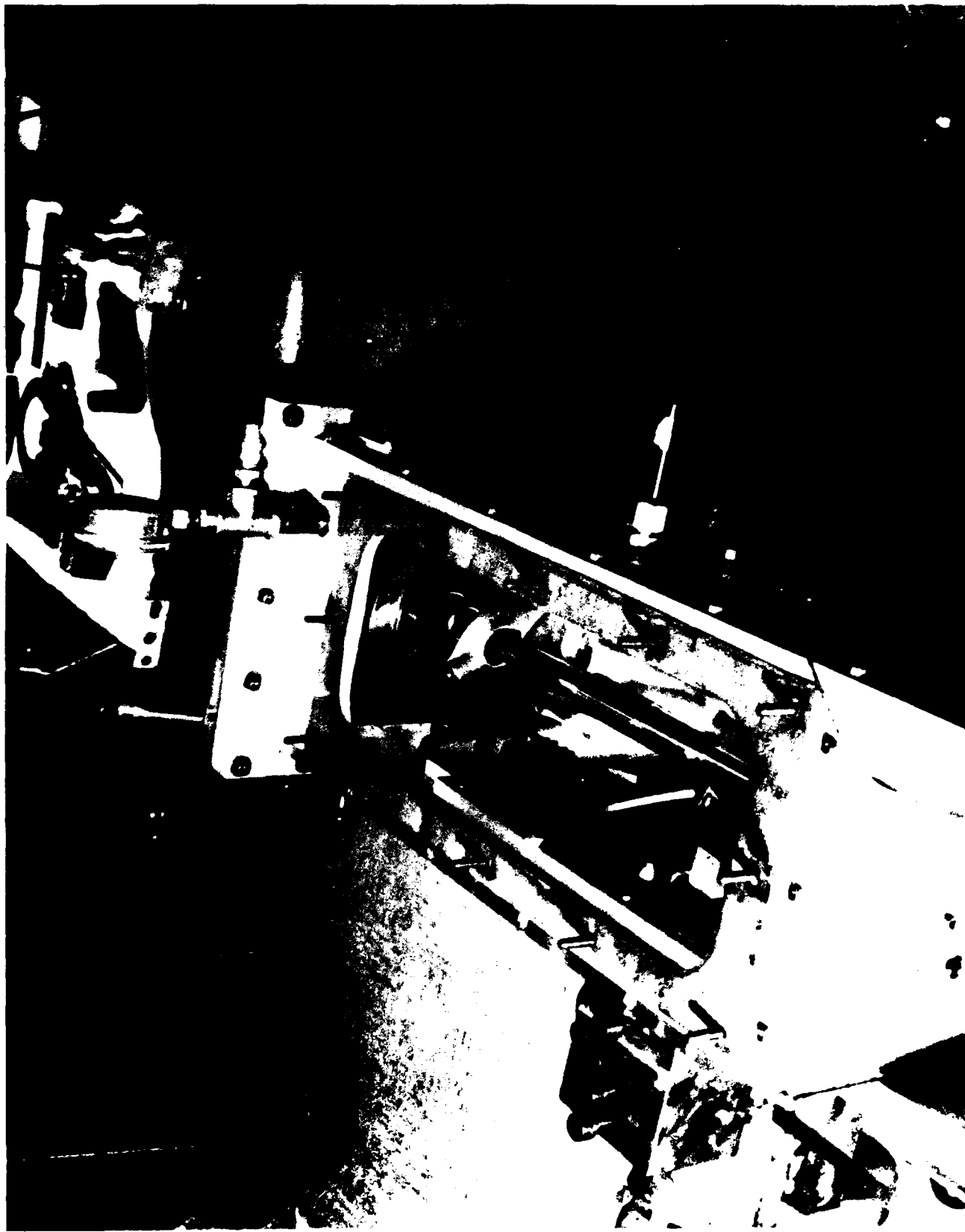


FIGURE 2 - TOP VIEW ENCLOSURE

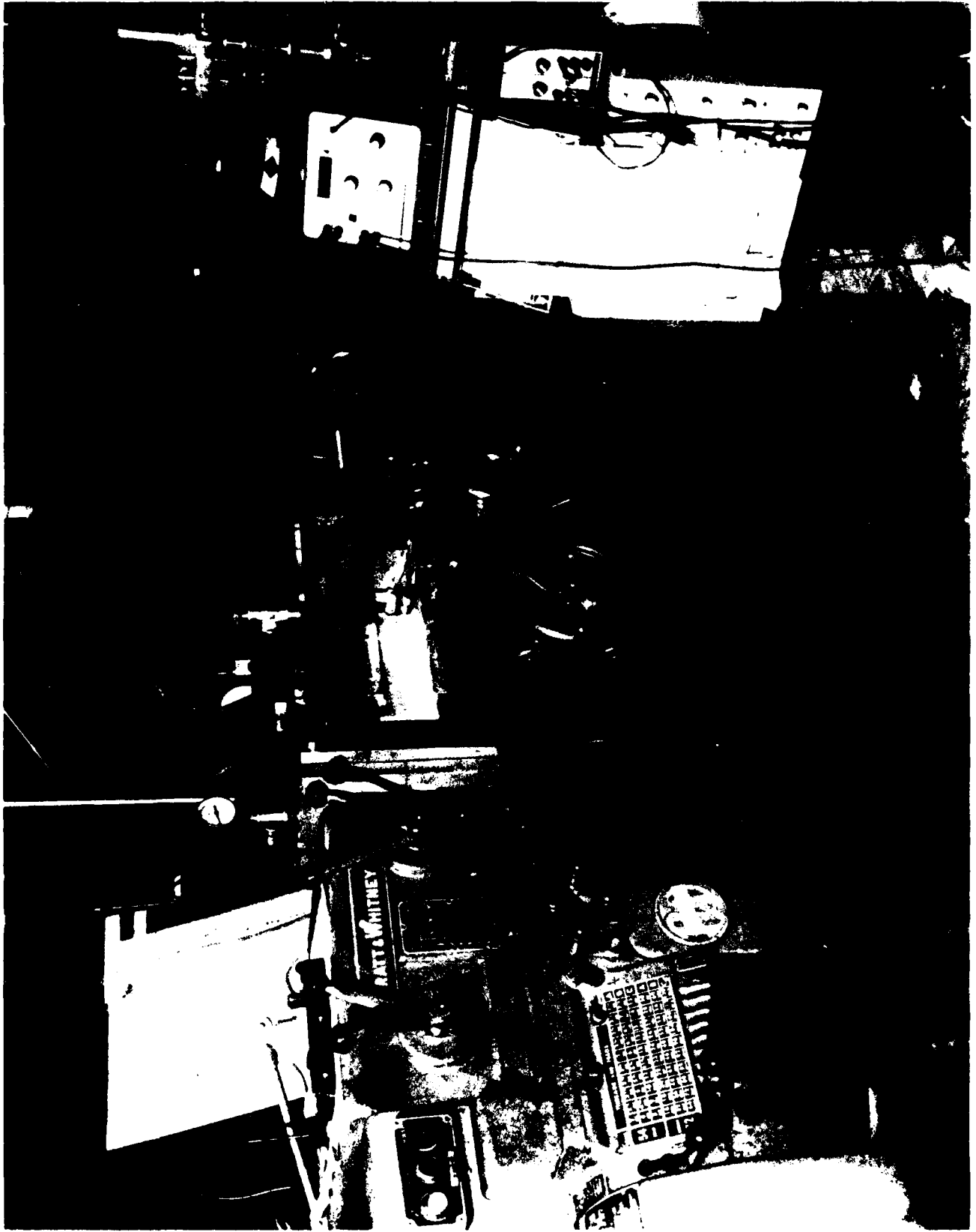
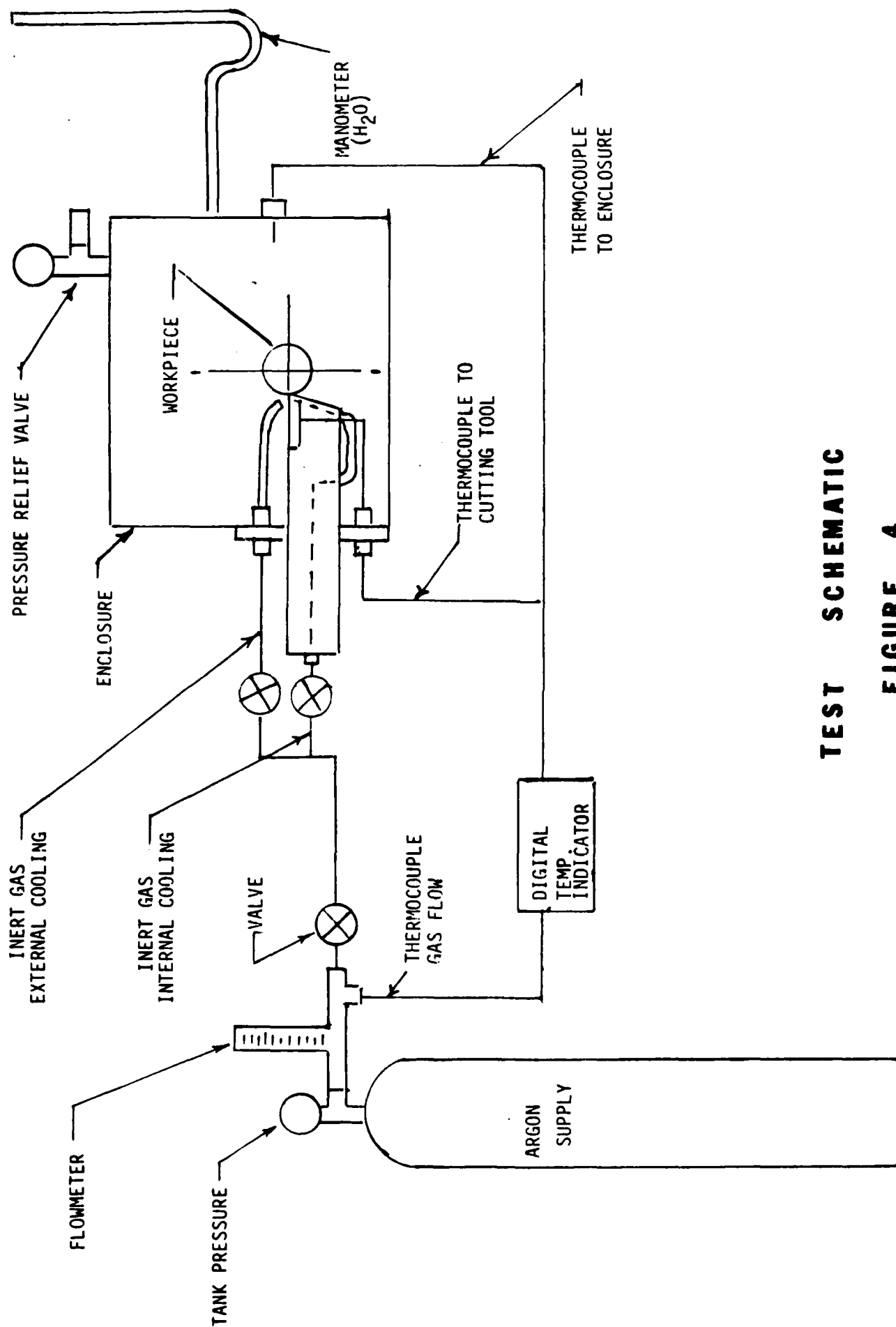
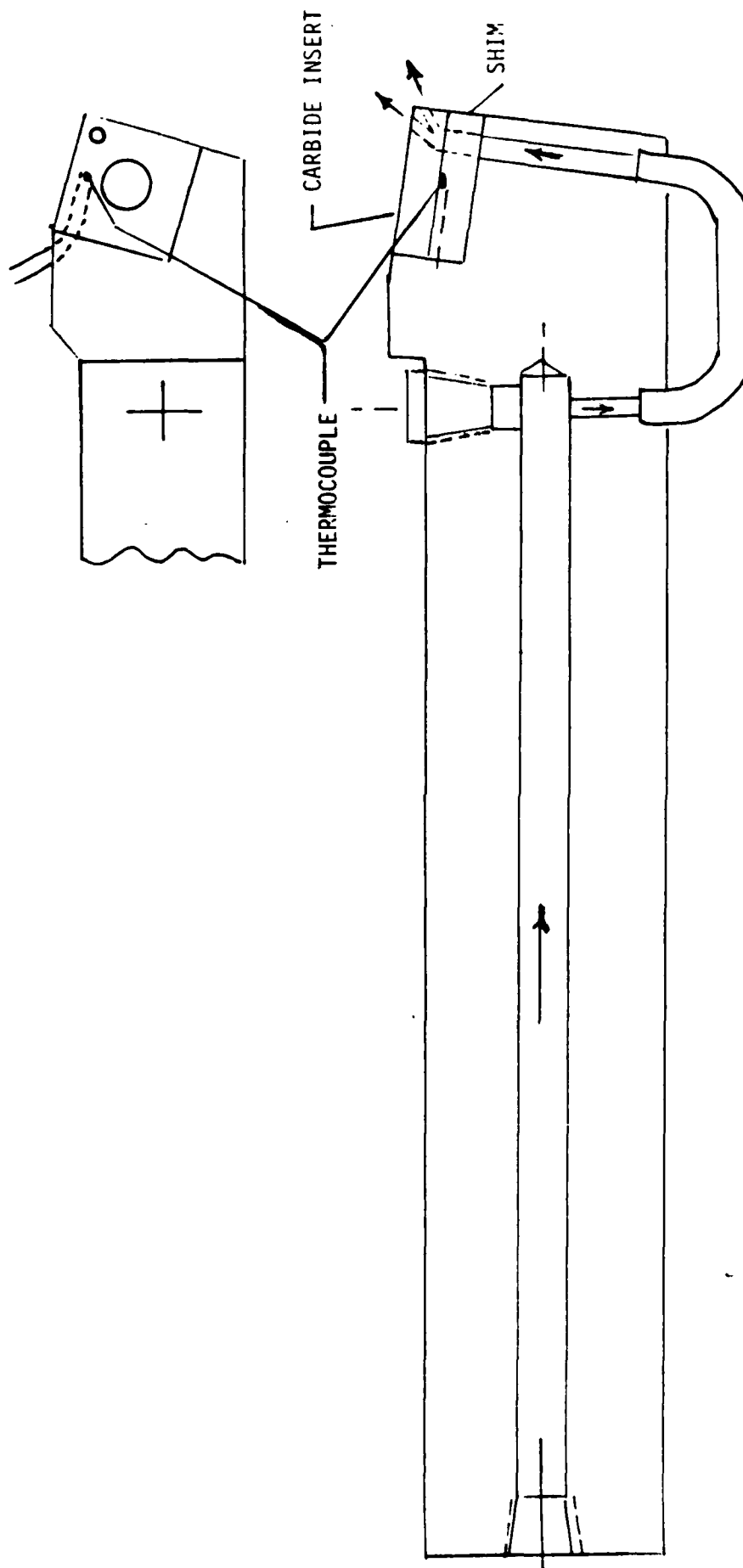


FIGURE 3 LATHE & PERIPHERAL EQUIPMENT



TEST SCHEMATIC

FIGURE 4



TOOLHOLDER

FIGURE 5

### 3.4 INSTRUMENTATION

#### 3.4.1 TEMPERATURE

"K" type chromel alumel thermocouples were used to indicate temperatures at the cutting tool, at the gas inlet and the ambient temperature inside the enclosure. A Biddle Versa Cal digital readout instrument was used to monitor instantaneous temperatures. A Leeds & Northrup Speedomatic, Type K-68, was used for the continuous strip chart recorder. Figure 6 shows the thermocouple calibration curve. A steel bar was machined, without coolant to determine the variation between the exact tool tip temperature and the tool insert thermocouple reading. An independent thermocouple was used to check the tool tip temperature.

#### 3.4.2 PRESSURE

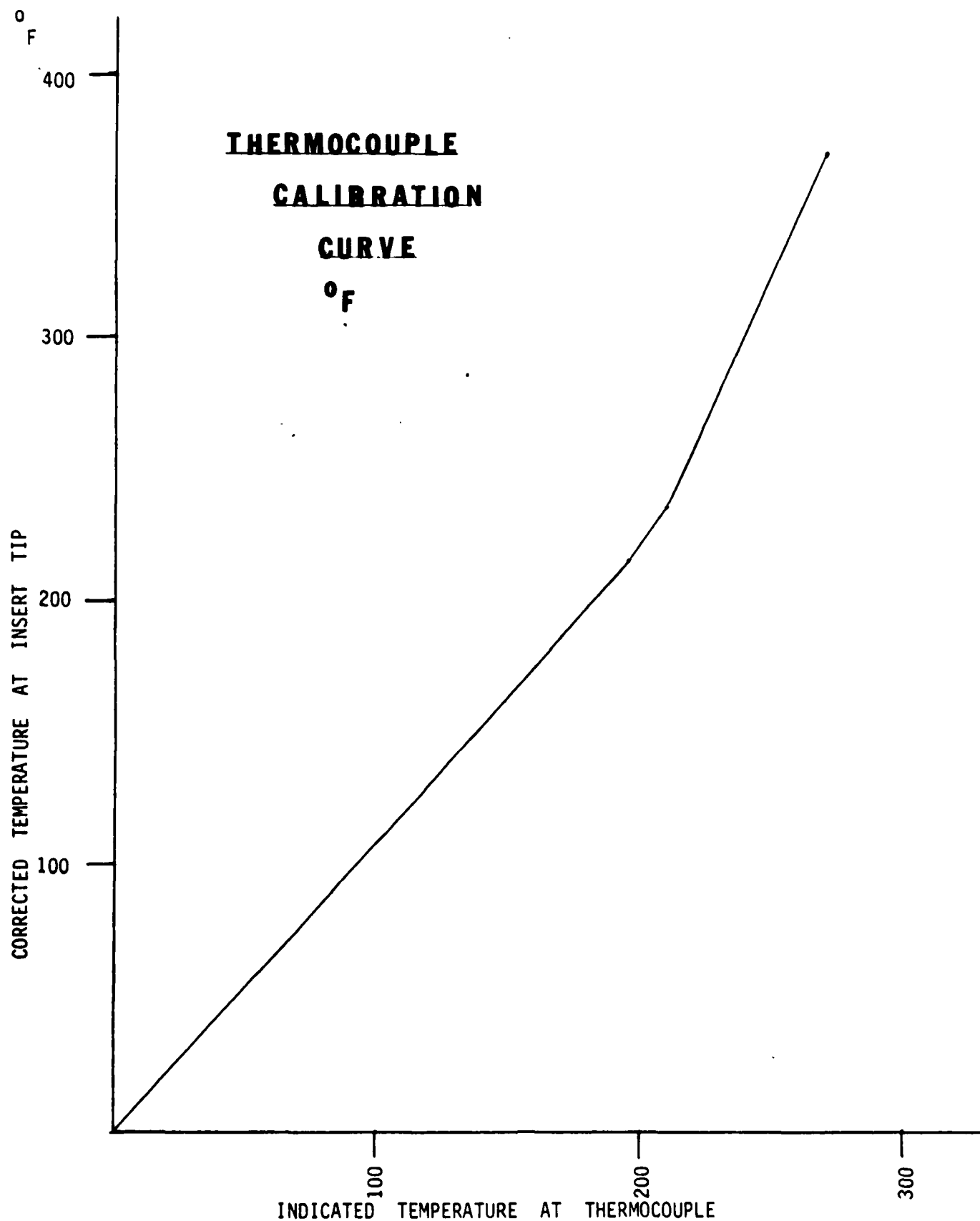
A simple water manometer was used to monitor the chamber pressure. A pressure relief valve, set at three (3) psi, was used to vent any overpressures. All tests were conducted at a positive (0.25 psi) pressure inside the enclosure.

#### 3.4.3 CHAMBER ATMOSPHERE

An oxygen analyzer, MSA Model No. 245R, was used to monitor the oxygen level inside the chamber during the tests. All tests were conducted with the oxygen level inside the chamber at less than 1.0%

#### 3.4.4 CHEMISTRY ANALYSIS

Luvac Corporation of Boylston, Mass. performed the chemistry analysis of the DU chips. A Leico-136 model was used for the oxygen analysis and a Leico EC-12 was used for the carbon analysis. Both instruments use a combustion/infra-red detection technique.



**FIGURE 6**

### 3.4.5 ARGON FLOW

An Oxweld Flowmeter, Type B, 0 to 60 CFH, was used to monitor the argon flow rates. Dry argon, provided by AMMRC, with a purity of 99.996% was used as the coolant and environmental media.

## 4.0 TEST EVALUATION

A series of ten (10) machining tests were conducted on GFM DU/0.75% Ti right cylindrical bars. Three (3) samples of the machine turnings from each bar were submitted for analysis.

### 4.1 GFM/DU BAR STOCK

Twelve (12) each DU/0.75% Ti bars were provided by AMMRC for experimental machining. The bars were nominally 1.22-inches in diameter by 14.125-inches long, age hardened to Rc41 to Rc43. Chemistry analysis of the heat indicated an initial carbon range from 30 ppm to 80 ppm. The chemistry analysis did not include the oxygen content.

Wafers were cut from the bottom of each bar and submitted for an independent analysis. Results were as follows:

TABLE I

<u>Bar No.</u>	<u>Sample No.</u>	<u>(Grams) Weight</u>	<u>Oxygen</u>	<u>PPM</u>	<u>Carbon</u>
K09 - 807	601	8.0	29		40
K09 - 107	602	9.0	34		30
K09 - 407	603	14.0	49		40
K09 - 908	604	5.5	39		30
K10 - 306	605	8.5	60		40
K10 - 906	606	7.0	40		50
K09 - 907	607	8.5	40		50
K09 - 304	608	10.0	45		50
K09 - 808	609	11.0	38		50
K09 - 707	610	7.0	46		40
K09 - 106	611	7.0	32		50

#### 4.2 DENSITY CHECKS

Using measured weights and dimensions, an approximate average density of 18.6 grams/cc was calculated for three (3) representative bars. This was done to check any gross impurities.

#### 4.3 TEST PROCEDURE

The procedure shown in Appendix A was used as a guide in the performance of the tests. Data sheets were executed for each test and are shown in Appendix B.

#### 4.4 "OPEN AIR" TEST

This test was made on Bar # K09 - 807, without the use of the enclosure and using a water-soluble oil as a coolant. Results were as follows:

TABLE II

<u>Bar #</u>	<u>Test #</u>	<u>Sample #</u>	<u>Oxygen</u>	<u>PPM</u>	<u>Carbon</u>
K09 - 807	Open Air	107	318		100
K09 - 807	Open Air	108	219		80
K09 - 807	Open Air	109	109		100

Test parameters are shown in Appendix B - "Test Data".

In addition to this open air test, another chip was chosen indiscriminately from the lathe bed and submitted for analysis. In all probability, this chip had been exposed to air and water for a long period of time. Chemistry results indicated:

507 ppm	Oxygen
520 ppm	Carbon

#### 4.5 "CONTROLLED ATMOSPHERE" TESTS

A series of nine (9) machining tests were performed under controlled conditions as described in the data sheets in Appendix B. Operating parameters were adjusted to optimize results. The chemistry results are shown in the following table.

TABLE III

<u>Bar #</u>	<u>Test #</u>	<u>Sample #</u>	<u>Oxygen</u>	<u>PPM</u>	<u>Carbon</u>
K09 - 807	1	201	89		30
		202	80		50
		203	77		80
K09 - 107	2**	204	128**		70
		205	139**		70
		206	129**		90
K09 - 407	3	207	52		50
		208	69		60
		209	83		60
K09 - 908	4	210	76		50
		211	95		40
		212	103		50
K10 - 306	5	213	81		60
		214	115		80
		215	96		90
K10 - 906	6	216	59		60
		217	69		70
		218	63		73
K09 - 907	7	219	63		30
		220	71		40
		221	94		80
K09 - 808	8	222	60		30
		223	56		30
		224	68		40
K09 - 707	9	225	51		20
		226	63		40
		227	84		50

\*\*High oxygen content is attributed to low gas pressure in the argon bottle and the corresponding high tool temperature, as shown on the data sheets in Appendix B.

The average of 76ppm - oxygen, cited in the summary, excludes the three high analyses in test #2.

A composite of the above data is shown in Tables IV and V.

PPM:O<sub>2</sub>

TABLE IV

O<sub>2</sub> ANALYSIS  
COMPOSITE DATA

TOOL TEMP °F

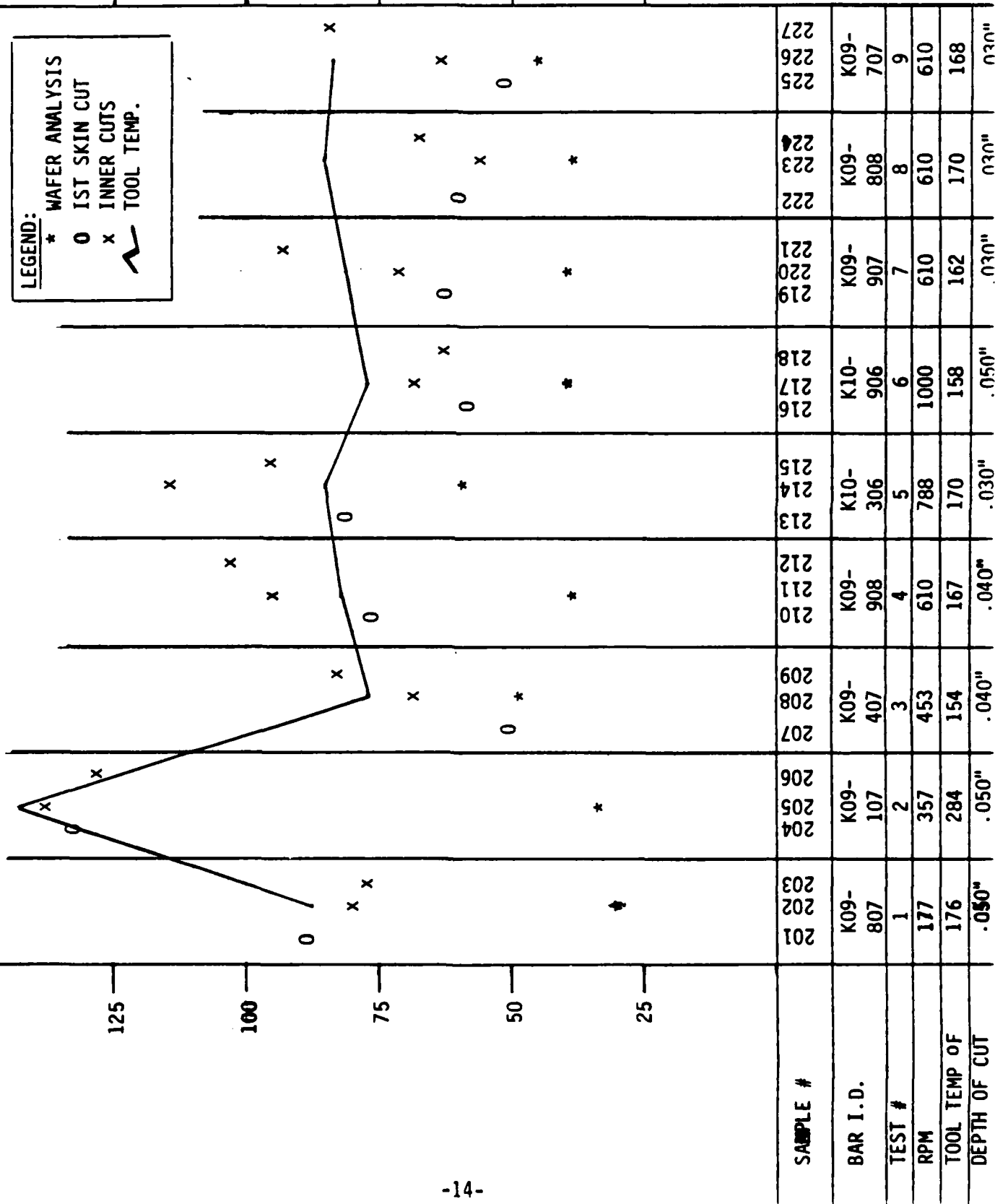
## LEGEND:

\* WAFER ANALYSIS

0 1ST SKIN CUT

x INNER CUTS

✓ TOOL TEMP.





#### 4.6 OBSERVATIONS

During these machining tests, several significant items were noted:

- Machine turnings that were relatively free of oxide contamination were bright and lustrous, with an appearance comparable to a clean steel chip.
- With a slight increase in the oxide level, the chips discolor very rapidly. During the "check-out" tests and test #2, it was immediately obvious that a reaction was occurring, by observing the discoloration of the chip as it was being machined. The chemistry results confirmed these predicted high oxide levels.
- During the chemistry analysis, the DU chips were exposed to air for a period of ten to fifteen minutes to perform the weighing operation. In addition, the oxygen level inside the chamber rose to approximately 10%, when the top cover was removed and the chips were placed in the identified containers. Both of these operations could have contributed to the oxygen content of the chips. With a totally enclosed system (from lathe to melting), this exposure to air would be eliminated.
- During test #2, the argon pressure in the gas bottle dropped below 500 psi; the tool temperature rose appreciably. The moisture content in the argon (quoted at 10 ppm) could have been the contributing factor to the high oxide level in chips. A cold trap and maintaining adequate minimum gas pressure throughout the machining operations should eliminate this problem.

- By maintaining the gas inlet temperature at approximately 50<sup>0</sup>F and the gas pressure in the bottle at greater than 1000 psi, the corresponding tool temperature was held at 170<sup>0</sup>F or below. These operating parameters provided the best results over the last four tests.
- The only operating parameters changed throughout the tests were the speeds (RPM) and depth of cuts. No appreciable impact on the overall results was noted due to these changes.
- One anomaly noted in the chemistry results was the lower oxide level in the "skin" cuts from each DU bar. It was expected that the outer surface of the bar would be higher, due to its prolonged exposure to air.
- Visual observation of the tool wear indicated no obvious deterioration; this was confirmed by the low carbon pick-up on all tests. However, more detailed studies should be performed in this area.
- In production operations, the analysis of the resultant heat from the melting of the DU chips would be the criteria for rejection or acceptance of the material for subsequent reprocessing into DU penetrators. Therefore, the averages of the oxygen and carbon content in the starting material (wafer analysis) and in the final machine turnings (chip analysis) would closely approximate the total contaminants in the heat:

	<u>AVERAGE CARBON (PPM)</u>	<u>AVERAGE OXYGEN (PPM)</u>
Starting Material (Wafer Analysis) . . . . .	43	41
Final Material (Chip Analysis) . . . . .	53	76
	<hr/>	<hr/>
Net "Change"	10	35

## 5.0 CONCLUSIONS

The results discussed above have been obtained on a small scale system. However, it is reasonable to conclude that this data could be extrapolated to larger, overall systems. The generation of "contaminant-free" chips, as accomplished in this Phase I program, is the first step in providing a successful DU chip recovery system.

As an adjunct to this study, some chips were placed in a small graphite crucible, coated with yttria, and inserted into an electric resistance furnace for melting. The chips were held at a temperature of 2700<sup>0</sup>F for a period of one (1) hour. These chips were successfully melted into a solid mass.

## 6.0 RECOMMENDATIONS

On the basis of exploratory results obtained during the course of this work, it is clear that additional effort *should be directed toward* several potential problem areas:

### 6.1 MACHINING

Due to the unique nature of this gas-cooled process, SCI suggests a machining study to assure compatibility with existing machining programs, cycle times and production output, as follows:

6.1.1 Duplicate tool insert materials, feeds, speeds and depth of cuts currently being used by penetrator manufacturers; all work to be performed under an argon atmosphere.

6.1.2 Perform a tool wear study under the above conditions.

6.1.3 Optimize inert gas flow to control chip temperature.

## 6.2 MELTING TECHNIQUES

The purpose of this investigation would be to find the best and most economical method of converting "pure" chips into solid, usable material. Some areas to consider:

6.2.1 Electric resistance melting.

6.2.2 Vacuum induction/continuous melt.

## 6.3 ARGON RECYCLING

The purpose of this study would be to provide a safe, economical and practical system for providing argon to the various enclosures. The following are suggested for further investigation:

6.3.1 Gas alarm systems and hazard analysis.

6.3.2 Equipment for separation of air and other impurities in the recycling system.

6.3.3 Continuous argon and air monitoring devices.

6.3.4 Gas purity requirements.

## 6.4 ENCLOSURE CONCEPTS

The purpose of this study is to develop design concepts for the CNC lathes, conveyers, and other peripheral equipment as follows:

6.4.1 Develop isolation mechanisms to insure an inert atmosphere during shutdown and maintenance periods.

6.4.2 Maintenance accessibility.

6.4.3 Service lines to all equipment.

6.4.4 Shutdown procedures.

6.4.5 Rod blank entry/penetrator exit.

6.4.6 Safety aspects for chip handling.

6.4.7 Minimize effects on other lathe operations, in the event of a shutdown.

6.4.8 Vacuum pumps/manifolds/exhaust systems/filters/accumulators.

#### A C K N O W L E D G M E N T S

The authors wish to express their appreciation to G. Bruggeman, H. Whitney, E. Emerson, R. Folvin, F. Hodi, S. Clemente, and P. Burke of AMMRC for their participation and active interest in the program and their cooperative assistance in carrying it to a successful completion.

A P P E N D I X    A

TEST PROCEDURE

## APPENDIX A

### CHIP RECOVERY PROGRAM DAAG46-83-C-0004

#### MACHINING TEST PROCEDURE

##### REPRODUCIBILITY TESTING

After obtaining optimum temperature and gas flow rates in the equipment "check out" phase, a series of ten (10) tests will be conducted as a verification phase of the program.

##### I. "OPEN-AIR" TEST

To provide a data base, the first DU bar will be machined, using a water soluble oil, in the open atmosphere. Chips will be analyzed for oxygen and carbon content. The outer layer or first "skin" cut will be analyzed separately. 200 grams of chips will be analyzed for this test.

##### II. "CONTROLLED ATMOSPHERE" TESTS

A series of nine (9) tests will be performed to verify results. The objective of these tests is to determine general operating parameters that will minimize any oxygen or carbon "pick-up" in the machining chips. The following procedures will be followed:

1. Identified sample containers will be placed in the enclosure before start of test.
2. Place identified DU bar into enclosure; set up for cutting.
3. Seal enclosure; purge and pressurize with argon and check oxygen level.
4. Record initial data on the test data sheet: (Attachment #1)
  - (a) Test number.
  - (b) DU bar identification number.
  - (c) Date
  - (d) Initials
  - (e) Start time
  - (f) Tool insert identification
  - (g) Temperatures
  - (h) Rates
  - (i) Pressures

MACHINING TEST PROCEDURE (Continued - page 2)

5. After enclosure atmosphere reaches less than 1% oxygen, start machining (skin surface) with argon gas flow to cutting area.
6. Stop machining; with a minimum argon flow, open access to enclosure. Using long forceps, place chips in sample container. Seal and transfer chip samples to chemistry laboratory.
7. Seal and check condition of enclosure. Record temperatures, rates, and pressures where applicable, before starting second cut.
8. Vary operating parameters, as needed, to control tool temperature, ease of machining and best overall performance. Comment sheets will be attached to the data sheet to denote any changes made during the test. (Attachment #2).
9. After approximately 200 grams of chips are generated, step (6) will be repeated for the transfer of samples to chemistry.
10. Analyze DU chips for oxygen and carbon content.
11. Results of chemistry analysis will be evaluated before proceeding with the next test. A 24 hour "turn-around" in chemistry will be necessary to expedite the machining tests.
12. Record all necessary data at the end of test:
  - (a) Enclosure pressure
  - (b) Enclosure temperature
13. Proceed with the next test (new DU bar), following the same procedure.

DATE \_\_\_\_\_

**INITIALS** \_\_\_\_\_

## SEQUENTIAL CUTS

[illegible]

MACHINING TEST PROCEDURE

DAAG46-83-C-0004

Test # \_\_\_\_\_

Date \_\_\_\_\_

Bar # \_\_\_\_\_

Initials \_\_\_\_\_

COMMENTS:

A P P E N D I X   B

DATA SHEETS

5/18/83

BAR # K09-807

1st Test

INITIALS JTC

DAG46-83-C-0004

SEQUENTIAL CUTS

DATA	Start	1st	2nd	3rd	4th	5th	6th	7th	8th	End
Time		A.M. 10:40	10:55	11:00	11:20	11:25	P.M. 3:05	3:10	3:15	
Sample container #		201	Scrap	Scrap	202	203	107	108	109	
Insert Ident. (rate)	C-2 883	50Neg.					1PG 432	50Neg.		
Temperatures Enclosure OF	70	71	72	74	73	74	--	--	--	
Tool (Max.) OF	69.4	110	160	182	160	176	--	--	--	
Gas flow OF	46	46	40	42	39.6	40.1	--	--	--	
Accumulator										
Rates Gas flow CFM		2.0								
Tool Feed "/Rev		.0155	.0155	.0155	.0100	.0100	.0155	.0155	.0155	
Speed (RPM)		276					302			
Depth of cut "		.020	.050			.045	.020	.050	.050	
Pressures Leak rate % O2		<1.0					--	--	--	
Enclosure PSI		0.25					--	--	--	
Argon flow										
Accumulator										

ATTACHMENT #1

**MACHINING TEST PROCEDURE (Continued - page 2)**

**DAAG46-83-C-0004**

**Test #** Final (1st Test)

**Date** 5/18/83

**Bar #** K09-807

**Initials** JTC

**COMMENTS:**

- . Cut outer (oxide) skin (.020") (sample #201)
  - . Cut and removed next layer (.050") of chips (scrap)
  - . Cut and removed next layer (.050") of chips (scrap)
  - . Cut next layer (.050") and samples (#202)
  - . Cut next layer (.050") and samples (#203)
  - . Submitted samples to LUVAC at noon
  - . Used same bar for "open air" tests, using a water soluble oil as a lubricant
  - . Used approximate feeds and speeds as the enclosure test
  - . Sampled outer skin (#107)
  - . Removed .050" layer and scrapped
  - . Cut .050" and sampled (#108)
  - . Cut .050" and sampled (#109)
- } Submitted to LUVAC 5/19/83 1:00 P.M.

LUVAC Results	RPM	
	O2	C
#201	89	30
#202	80	50
#203	77	80
#107	318	100
#108	219	80
#109	170	100

(Received 5/19/82 4:30 P.M.)

4/19/83

INITIALS JTC

BAR # K09-107

2nd Test

DAAG46-83-C-0004

## SEQUENTIAL CUTS

DATA	Start	1st	2nd	3rd	4th	5th	6th	7th	8th	End
Time		A.M. 11:00	11:05	11:10	11:15	11:20				
Sample container #		204	Scrap	Scrap	205	206				
Insert Ident. (rake)	C-2 883	50Neg.								
Temperatures Enclosure OF	72	73	72.5	73	73	73				
Tool (Max.) OF	74.5	284	240	267	277	283				
Gas flow OF	71.0	66	55	64	63	64				
Accumulator										
Rates										
Gas flow CFM		2.0								
Tool Feed "/Rev.		.010								
Speed (RPM)		357								
Depth of cut		.020	.050			.045				
Pressures										
Leak rate PSI		<1.0								
Enclosure PSI		0.25								
Argon flow										
Accumulator										

ATTACHMENT #1

**MACHINING TEST PROCEDURE (Continued - page 2)**

**DAAG46-83-C-0004**

**Test #** Final (2nd test) **Date** 4/19/83

**Bar #** K09-107 **Initials** JTC

**COMMENTS:**

- . Cut outer layer (.020") and sampled (#204)
- . Chips appeared darker (bronze) in color
- . Noted argon pressure at 500 psi in bottle; temperature at the cutting tool was higher than previous test; gas flow temperature was approximately 20° higher than 1st test (Bar K09-807)
- . Removed two (2) layers of .050" each and scrapped.
- . Cut next .050" layer and sampled (#205)
- . Cut next .050" layer and sampled (#206)
- . Submitted samples to LUVAC at 1:30 P.M.
- . RPM increased from test #1

**Results (5/20/83)**

	PPM	
	02	C
#204	128	70
#205	139	70
#206	129	90

BAR # K09-407

5/24/83

INITIALS JTC

3rd Test

DAAG46-83-C-0004

SEQUENTIAL CUTS

DATA	Start	1st	2nd	3rd	4th	5th	6th	7th	8th	End
Time		A.M. 10:40	10:50	11:00						
Sample container #		207	208	209						
Insert Ident. (rake)	(K-68)	5° Neg.								
Temperatures Enclosure OF	74	74	73.6	73.8						
Tool (Max.) OF	74	154	153	154						
Gas flow OF	73.4	53.5	48.8	46.7						
Accumulator										
Rates Gas flow CFM		2.0								
Tool Feed "/Rev.		.010								
Speed (RPM)		453								
Depth of cut		.040"								
Pressures Leak rate % O <sub>2</sub>		<1.0								
Enclosure PSI		0.25								
Argon flow										
Accumulator										

ATTACHMENT #1

**MACHINING TEST PROCEDURE (Continued - page 2 )**

**DAAG46-83-C-0004**

**Test #** Final (3rd Test)

**Date** 5/24/83

**Bar #** K09-407

**Initials** JTC

**COMMENTS:**

- . Preliminary checks were made to eliminate the discolored chips
- . By maintaining high pressure (<500 PSI) in the argon bottle, the gas flow temperature was kept at a minimum of 520F.
- . Bright lustered chips were generated
- . Chips were submitted to LUVAC at 4:00 P.M.
- . Rpm increased from Test #2

**Results:**

	PPM	
	O <sub>2</sub>	C
#207	52	50
#208	69	60
#209	83	60

BAR # K09-908

4th Test

INITIALS JTC

5/24/83

DAAG46-83-C-0004

SEQUENTIAL CUTS

DATA	Start	1st	2nd	3rd	4th	5th	6th	7th	8th	End
Time		A.M. 11:10	11:15	11:20						
Sample container #		210	211	212						
Insert Ident. (rake)	(K-68)	50 Neg.								
Temperatures Enclosure	74									
Tool (Max.) OF		154	167	155						
Gas flow OF		50.5	49.5	48.5						
Accumulator										
Rates										
Gas flow CFM		2.0								
Tool Feed "/Rev.		.010								
Speed (RPM)		610								
Depth of cut		.040								
Pressures										
Leak rate % O <sub>2</sub>		<1.0								
Enclosure PSI		0.25								
Argon flow										
Accumulator										

ATTACHMENT #1

MACHINING TEST PROCEDURE (Continued - page 2)

DAAG46-83-C-0004

Test # Final (4th test)

Date 5/24/83

Bar # K09-908

Initials JTC

COMMENTS:

- . RPM increased from test #3
- . Maintained gas flow temperature at approximately 50°F
- . Noted that chips were "bright" with no discoloration.
- . Eliminated the "scrap" layers that were cut on previous tests, based on previous chemistry results.
- . Submitted samples to LUVAC 4:00 P.M.

Results:

	PPM	
	O <sub>2</sub>	C
#210	76	50
#211	95	40
#212	103	50

BAR # K10-306

5/24/83

INITIALS JIC

5th Test

DANG 46-83-C-0004

SEQUENTIAL CUTS

DATA	Start	1st P.M.	2nd	3rd	4th	5th	6th	7th	8th	End
Time		1:15	1:25	1:35						
Sample container #		213	214	215						
Insert Ident. (rake)	K-68	50Neg.								
Temperatures Enclosure OF	77.1									
Tool (Max) OF		163	166	170						
Gas flow OF		57	55	49						
Accumulator										
Rates										
Gas flow CEM "/Rev		2.0								
Tool Feed		.010								
Speed (RPM)		788								
Depth of cut		.030	.030	.050						
Pressures										
Leak rate % O <sub>2</sub>		<1.0								
Enclosure PSI		0.25								
Argon flow										
Accumulator										

ATTACHMENT #1

MACHINING TEST PROCEDURE (Continued - page 2)

DAAG46-83-C-0004

Test # Final (5th test) Date 5/24/83  
Bar # K10-306 Initials JTC

COMMENTS:

- . Increased RPM to 788
- . Took normal three (3) samples as per previous test
- . "Bright" chips noted
- . Submitted to LUVAC at 4:00 P.M.

Results

	PPM	
	02	C
#213	81	60
#214	115	80
#215	96	90

Note: Low pressure in bottle (~ 500 PSI)



**MACHINING TEST PROCEDURE (Continued - page 2)**

**DAAG46-83-C-0004**

**Test #** Final (6th Test)

**Date** 5/24/83

**Bar #** K10-906

**Initials** JTC

**COMMENTS:**

- . Increase RPM to 1000 (Max. on Pratt Whitney lathe)
- . Used new argon bottle for added pressure and cooling effect
- . Chips appeared "bright"
- . Submitted three (3) samples to LUVAC at 4:00 P.M.

**Results:**

	PPM	
	02	C
#216	59	60
#217	69	70
#218	63	73

BAR # K09-907

7th Test

5/25/83

INITIALS JTC

DAAG46-83-C-0004

SEQUENTIAL CUTS

DATA	Start	1st	2nd	3rd	4th	5th	6th	7th	8th	End
Time		A.M. 11:10	11:17	11:25						
Sample container #		219	220	221						
Insert Ident. (rake)	10°Neg.	(with breaker)								
Temperatures Enclosure										
Tool (Max.) °F		161	158	162						
Gas flow °F	52	53.5	52	52.3						
Accumulator										
Rates										
Gas flow CFM		2.0	2.0	2.0						
Tool Feed "/Rev.		.0155	.0155	.0155						
Speed (RPM)		610	610	610						
Depth of cut		.030	.030	.040						
Pressures										
Leak rate % O <sub>2</sub>		<1.0	<1.0	<1.0						
Enclosure PSI		0.25	0.25	0.25						
Argon flow										
Accumulator										

ATTACHMENT #1

**MACHINING TEST PROCEDURE (Continued - page 2)**

**DAAG46-83-C-0004**

**Test #** Final (7th Test) **Date** 5/25/83

**Bar #** K09-907 **Initials** JTC

**COMMENTS:**

- . 10<sup>0</sup> Neg. provided smaller chips; clean and "bright"
- . Reduced RPM to 610 for comparison data
- . Submitted to LUVAC at 4:00 P.M.
- . Gas pressure 2100 PSI

**Results:**

	PPM	
	02	C
#219	63	30
#220	71	40
#221	94	80

BAR # K09-808

5/25/83

INITIALS JTC

8th Test

DAG-66-83-C-0004

SEQUENTIAL CUTS

DATA	Start	1st	2nd	3rd	4th	5th	6th	7th	8th	End
Time		P.M. 1:15	1:20	1:25						
Sample container #		222	223	224						
Insert Ident. (rake)	10°Neg.	(with breaker)								
Temperatures Enclosure										
Tool (Max.) Of		157	149	170						
Gas flow Of		53	43.9	43.2						
Accumulator										
Rates Gas flow CEM		2.0	2.0	2.0						
Tool Feed "/Rev		.0155	.0155	.0155						
Speed (RPM)		610	610	610						
Depth of cut		.030	.030	.040						
Pressures Leak rate % O <sub>2</sub>		<1.0	<1.0	<1.0						
Enclosure PSI		0.25	0.25	0.25						
Argon flow										
Accumulator										

ATTACHMENT #1

**MACHINING TEST PROCEDURE (Continued - page 2)**

**DAAG46-83-C-0004**

**Test #** Final (8th test)

**Date** 5/25/83

**Bar #** K09-308

**Initials** JTC

**COMMENTS:**

- . Same parameters as test #7
- . Noted bright chips
- . Submitted samples to LUVAC at 4:00 P.M.
- . Gas Pressure 1800 PSI

**Results:**

**PPM**

	<u>O<sub>2</sub></u>	<u>C</u>
#222	60	30
#223	56	30
#224	68	40

BAR # K09-707

5/25/83

INITIALS JTC

9th Test

DAG46-83-C-0004

SEQUENTIAL CUTS

DATA	Start	1st P.M.	2nd	3rd	4th	5th	6th	7th	8th	End
Time		1:40	1:52	2:05						
Sample container #		225	226	227						
Insert Ident. (rake)	10°Neg	w/Breaker								
Temperatures Enclosure										
Tool (Max.) °F		160	156	168						
Gas flow °F		39.6	41.0	41.0						
Accumulator										
Rates										
Gas flow CFM		2.0	2.0	2.0						
Tool Feed "/Rev.		.0155	.0155	.0155						
Speed (RPM)		610	610	610						
Depth of cut		.030	.030	.040						
Pressures										
Leak rate % O <sub>2</sub>		<1.0	<1.0	<1.0						
Enclosure PSI		0.25	0.25	0.25						
Argon flow										
Accumulator										

ATTACHMENT #1

**MACHINING TEST PROCEDURE (Continued - page 2)**

**DAAG46-83-C-0004**

**Test #** Final (9th test)

**Date** 5/25/83

**Bar #** K09-707

**Initials** JTC

**COMMENTS:**

- . Same parameters as 7th and 8th tests
- . Noted bright chips
- . Gas pressure 1500 psi
- . Submitted samples to LUVAC at 4:00 P.M.

**Results:**

	PPM	
	O <sub>2</sub>	C
#225	51	20
#226	63	40
#227	84	50

TEST # Chips for Melt TestDATE 5/25/83BAR # K09-304INITIALS JIC

DAG46-83-C-0004

SEQUENTIAL CUTS

DATA	Start	1st	2nd	3rd	4th	5th	6th	7th	8th	End
Time		A.M. 10:15	10:17	10:18						
Sample container #		(K09-304	plastic box)							
Insert Ident. (rake)		15° Neg	w/ breaker							
Temperatures Enclosure										
Tool (Max.) °F		160	169	167						
Gas flow °F	54	51	50.2	51						
Accumulator										
Rates Gas flow										
Tool Feed		.0155		----->						
Speed (RPM)		610		----->						
Depth of cut		.030"		----->						
Pressures Leak rate % O <sub>2</sub>		<1.0		----->						
Enclosure PSI		0.25		----->						
Argon flow										
Accumulator										

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Machining Study for the Production of  
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P. Shevchik  
South Creek Industries, Inc.  
Rexford, New York 12148  
Technical Report AMMRC TR 83-42, July 1983  
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Final Report 5 January 1983 to 5 July 1983

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Anaerobic processes  
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The present depleted uranium (DU) machining process used in the production of the M774 and M833 DU penetrators incurs excessive costs due to the necessity for burial of the radioactive metal turnings (chips). The alternative to burial was the recycling of the chips to form usable depleted uranium thereby eliminating disposal problems and increasing the supply of depleted uranium. An inert atmosphere was proposed to produce contaminate-free chips that will allow remelting to required chemical specifications of the penetrator material. A lathe enclosure was designed to provide a controlled atmosphere of argon gas maintaining a positive pressure of 0.25 psi within. Dry argon gas was used as a coolant at the tool workpiece interface. The chips were analyzed for oxygen and carbon content; the contaminants most critical to the remelting of the chips. The chemical analysis showed consistently low oxygen and carbon "pick-up." The significance of these results was substantiated by the successful melting of depleted uranium chips in an electric resistance furnace at AMMRC.

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